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Long Term Resource Monitoring Program

Technical Report

93-T001

A Conceptual Model of the Upper Mississippi River System Ecosystem

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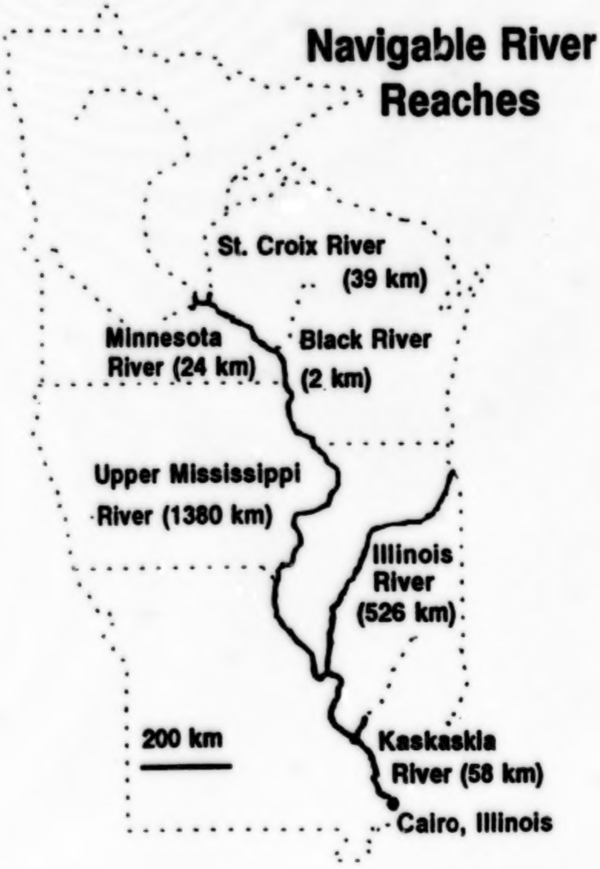
Navigable River Reaches

March 1993

A Conceptual Model of the Upper Mississippi River System Ecosystem

Ken Lubinski
U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, WI 54650

March 1993

This report is related to the efforts of the Ecological Research and
Evaluation Division, Environmental Management Technical Center.
At the time of publication of this report, Robert L. Delaney was Program
Manager, Barry W. Drazkowski was Deputy Program Manager, Dr. John W. Barko was
Technical Director, Dr. Ken Lubinski was Manager of the Population and
Community Ecology Group, and Terry D'Erchia was Writer-Editor.

This report was developed with funding provided by the
Long Term Resource Monitoring Program.

The standard review procedure for Long Term
Resource Monitoring Program Technical Reports includes
internal review by selected Environmental Management
Technical Center staff members, as well as review by
at least three external scientists competent
in the appropriate discipline(s).

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, an office of the U.S. Fish and Wildlife Service, in cooperation with the five Upper Mississippi River System states, Illinois, Iowa, Minnesota, Missouri, and Wisconsin, with guidance and program responsibility provided by the U.S. Army Corps of Engineers.

The mission of the LTRMP is to provide decision makers with information to maintain the Upper Mississippi River System (UMRS) as a viable large river ecosystem given its multiple-use character. The long term goals of the program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products.

The conceptual model described in this report is the initial product of LTRMP Strategy 1.1.1, *Describe Ecosystem* (USFWS 1992). It is intended to link empirical evidence available for the UMRS to stream ecology theory, and to provide a broad, system-level ecological framework upon which Program monitoring and research efforts can be based. The conceptual model will be reviewed and updated routinely as new information about the UMRS is obtained.

This report should be cited as:

Lubinski, K. 1993. A conceptual model of the Upper Mississippi River System ecosystem. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 93-T001. 23 pp.

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Introduction

The floodplain rivers of the Upper Mississippi River System (UMRS) (Fig. 1) are subject to many natural and human-induced disturbances. Combinations of disturbances frequently overlap in time and spatial scale. Multiple disturbances can result in complex ecological responses that resist explanation and limit the ability of resource managers to evaluate and solve resource problems.

A conceptual model is a description of what is presently known or believed about a system. The use of a conceptual model can improve resource managers' understanding of disturbances and ecological responses. This report describes the UMRS ecosystem using a conceptual model and discusses how this model can be used in developing Long Term Resource Monitoring Program (LTRMP) strategies. The model lists and describes major factors and disturbances occurring at five spatial scales: basin, stream network, floodplain reach, navigation pool, and habitat. During LTRMP implementation, the conceptual model is expected to provide an ecological foundation for setting Program priorities, directing investigations, and guiding experimental designs.

Definitions

Major factors, both biological (biotic) and non-biological (abiotic), act to maintain the ecosystem within certain limits over reference time periods (Fig. 2). For instance, light availability during growth and reproductive periods is thought to be a major factor controlling the distribution and abundance of submerged aquatic plants in the UMRS. Abiotic factors tend to exert more control over ecosystem processes in streams and rivers than do biotic processes (Ryder and Pesendorfer 1989).

A disturbance is an event that disrupts biology at the ecosystem, community, or population level (Pickett and White 1985; Resh et al. 1988; Sparks et al. 1990; Fig. 2). A disturbance can be natural or human-induced and may be temporary (e.g., a catastrophic flood) or permanent (e.g., the impoundment of a river reach). Frequently, a disturbance benefits one species or group of species while adversely impacting another.

A disturbance refers to an ecological response to an atypical occurrence, as opposed to a resource problem, which exists when an element of the ecosystem reaches a level of public concern. Increased sedimentation in the UMRS is a well known resource problem that is expected to cause the loss of many river backwaters over the next 50 to 200 years (Bellrose et al. 1979; McHenry et al. 1984). Resource components are ecosystem elements that are monitored as indices of ecosystem health or integrity.

Temporal and Spatial Scales

Studies of aquatic ecosystem responses to disturbances are increasingly using hierarchical systems of temporal and spatial scales (Petts 1989; Ward 1989a). Generally, disturbances at small spatial scales occur within relatively short temporal scales, and disturbances at large spatial scales occur at longer temporal scales (Ward 1989a). Our approach to understanding relevant past and future disturbances to the rivers in the UMRS includes

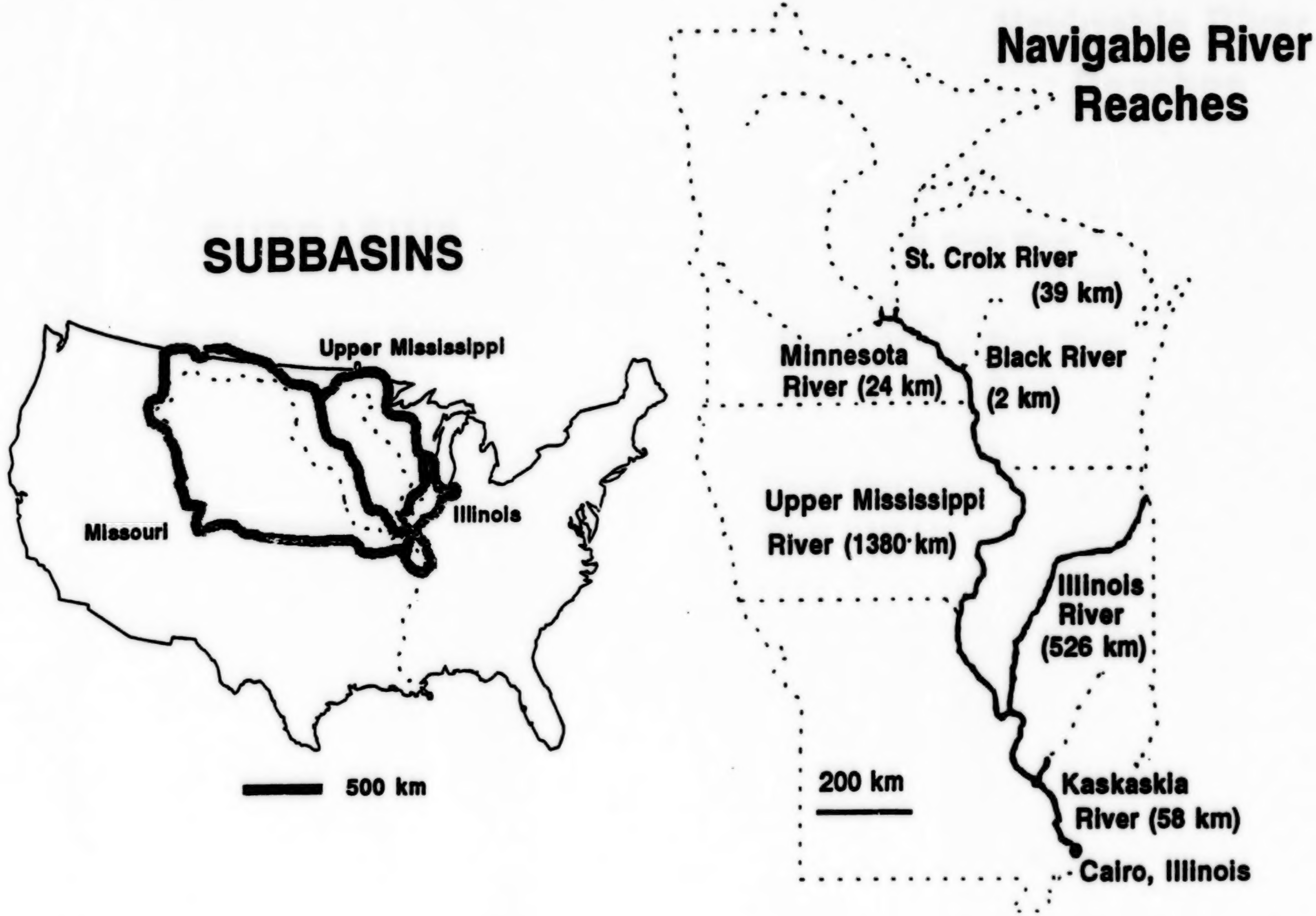


Figure 1. The navigable river reaches of the Upper Mississippi River System and subbasins above Cairo, Illinois

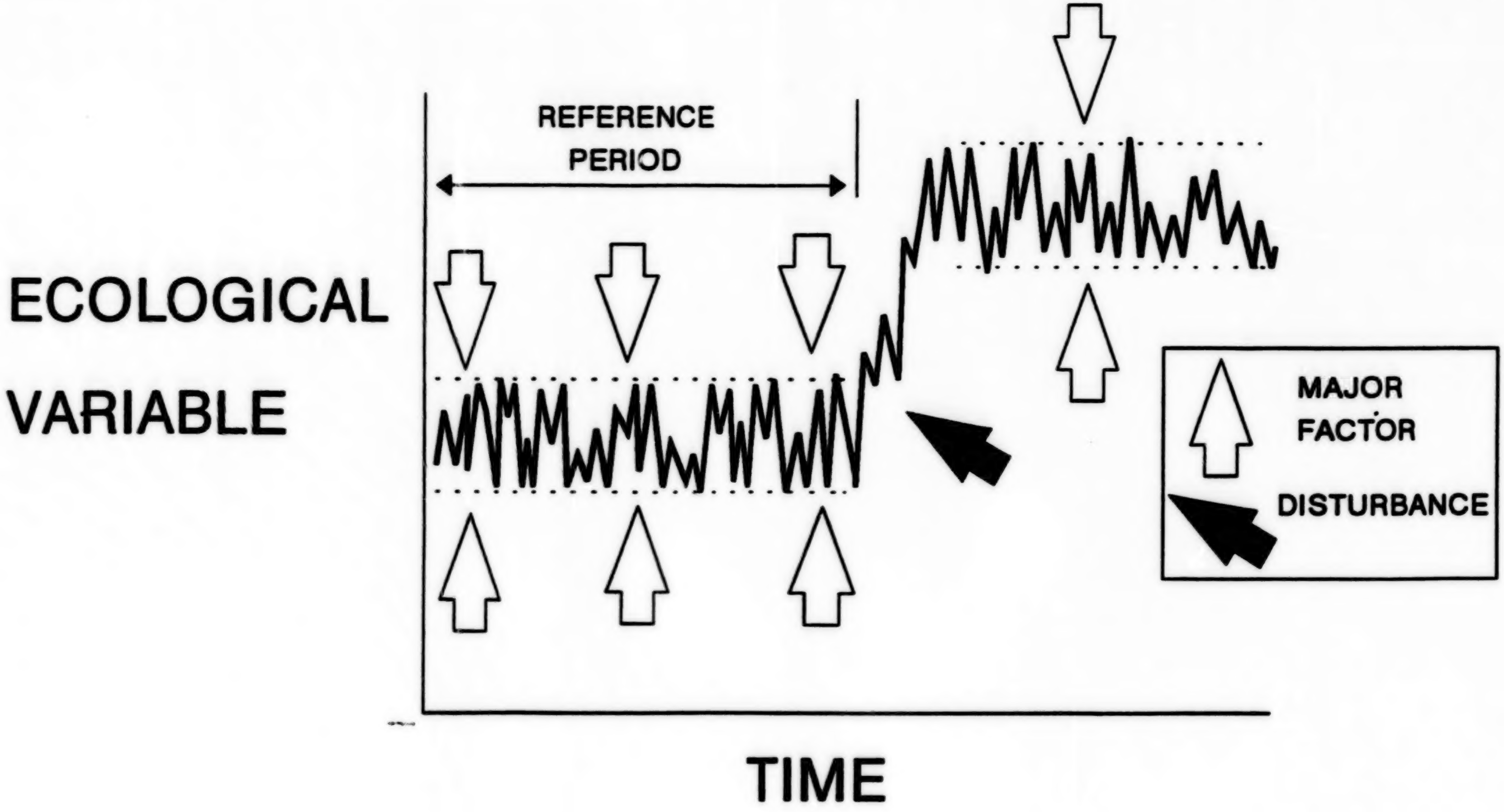


Figure 2. Major factors keep ecological variables within specific limits. A disturbance causes the variable to exceed these limits.

evaluations at two temporal scales (reference periods) and five spatial scales.

Two reference time periods are useful for defining long term disturbances in the floodplain rivers of the UMRS. Presettlement ecosystem conditions were those that existed in the 500- to 1,000-year period prior to 1800 when Europeans began colonizing sites along the rivers (Fig. 3). Theoretically, the UMRS ecosystem, having adapted to postglacial climate conditions, existed in a relatively stable equilibrium during the presettlement period. Post-dam ecosystem conditions were those during the 5- to 10-year period following construction of each of the navigation dams (in the 1930s for most of the dams; 1913 for the dam at Keokuk, Iowa). Studies of ecological changes associated with sedimentation during the last 50 years, for example, frequently compare present conditions to post-dam conditions.

Spatial Scales

The five spatial scales used to describe ecosystem structure and function in the UMRS are basin, stream network, floodplain reach, navigation pool, and habitat. Major factors and disturbances that operate at any one scale can also, through more specific mechanisms, control ecological structure or function at smaller scales. In addition, a small-scale disturbance, if repeated often enough or at many locations, can have cumulative impacts at larger scales.

Basin Scale

The basin is the accepted fundamental land unit for studies of river ecology (Petts 1989). The Mississippi River Basin above Cairo, Illinois, covers 1.86 million km². Major subbasins include those of the Upper Mississippi, Illinois, and Missouri Rivers (Figs. 1, 4).

Geology, climate, and vegetative cover are the major factors regulating ecosystem processes in the river basins (Bhowmik et al. 1984; Resh et al. 1988). Earthquakes act as geologic disturbances at this scale, particularly in the New Madrid area (Simons et al. 1981).

Glacial events prior to 12,000 BP (before present) were natural climatic disturbances that had dramatic impacts on the ecology of the Upper Mississippi River Basin (Fremling and Claflin 1984; Nielsen et al. 1984). Their major effects were leveling the topography of the area and providing postglacial surficial materials (Nielsen et al. 1984). Loess blown by postglacial winds now forms a mantle over half of the Upper Mississippi and Illinois Subbasins and serves as a major source of silt in the UMRS ecosystem (Nielsen et al. 1984).

The Upper Mississippi River Basin has a temperate, humid climate (U.S. Army Engineer District, St. Louis et al. 1970; Slizeski et al. 1982). The latitudinal range of the Basin (37° to 48° north) covers approximately 1,300 km (800 mi). Air and water temperatures at any time of the year can vary greatly across the Basin's north-south axis, and seasonal events at the

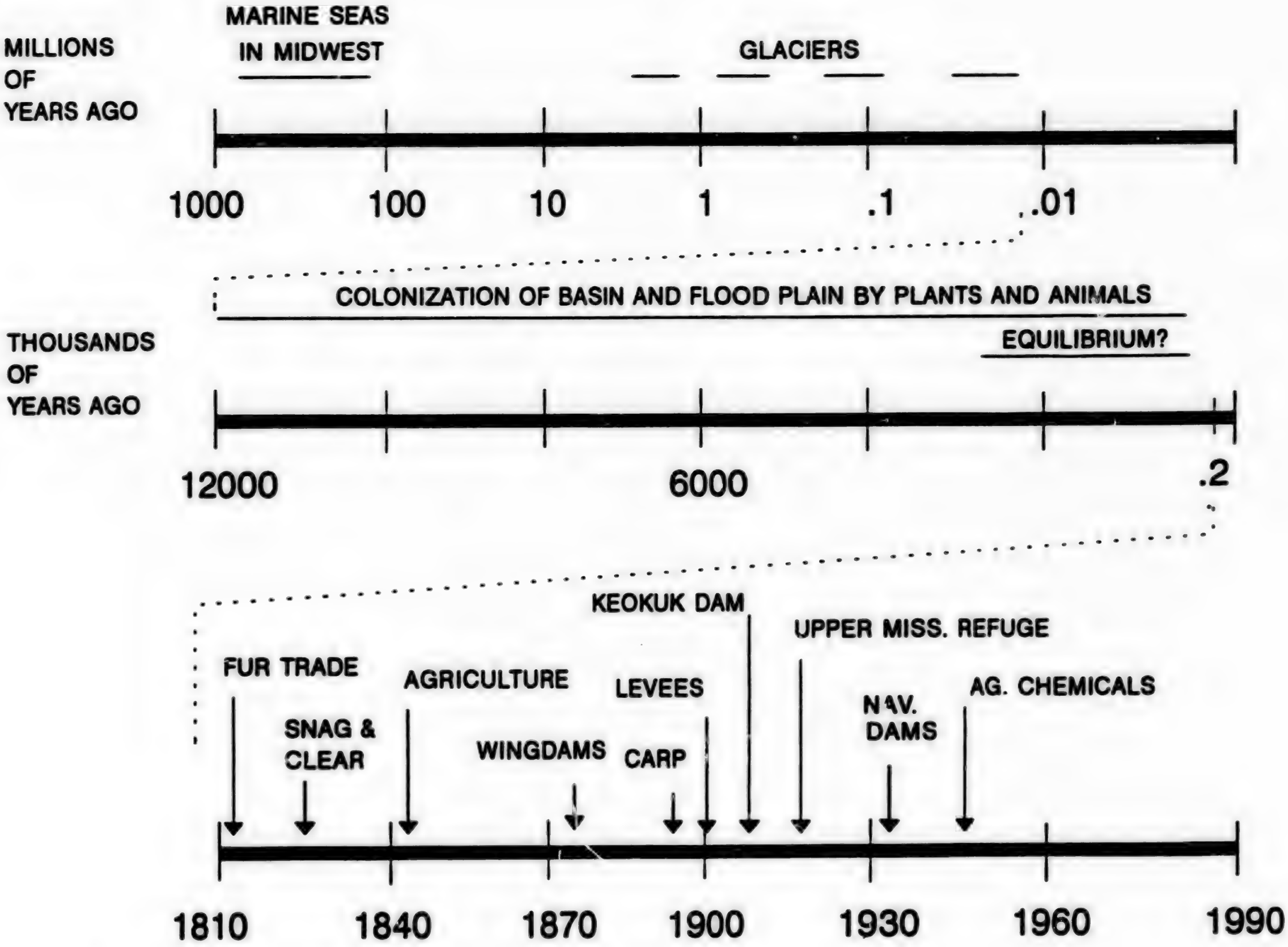


Figure 3. Upper Mississippi River System ecological time scales

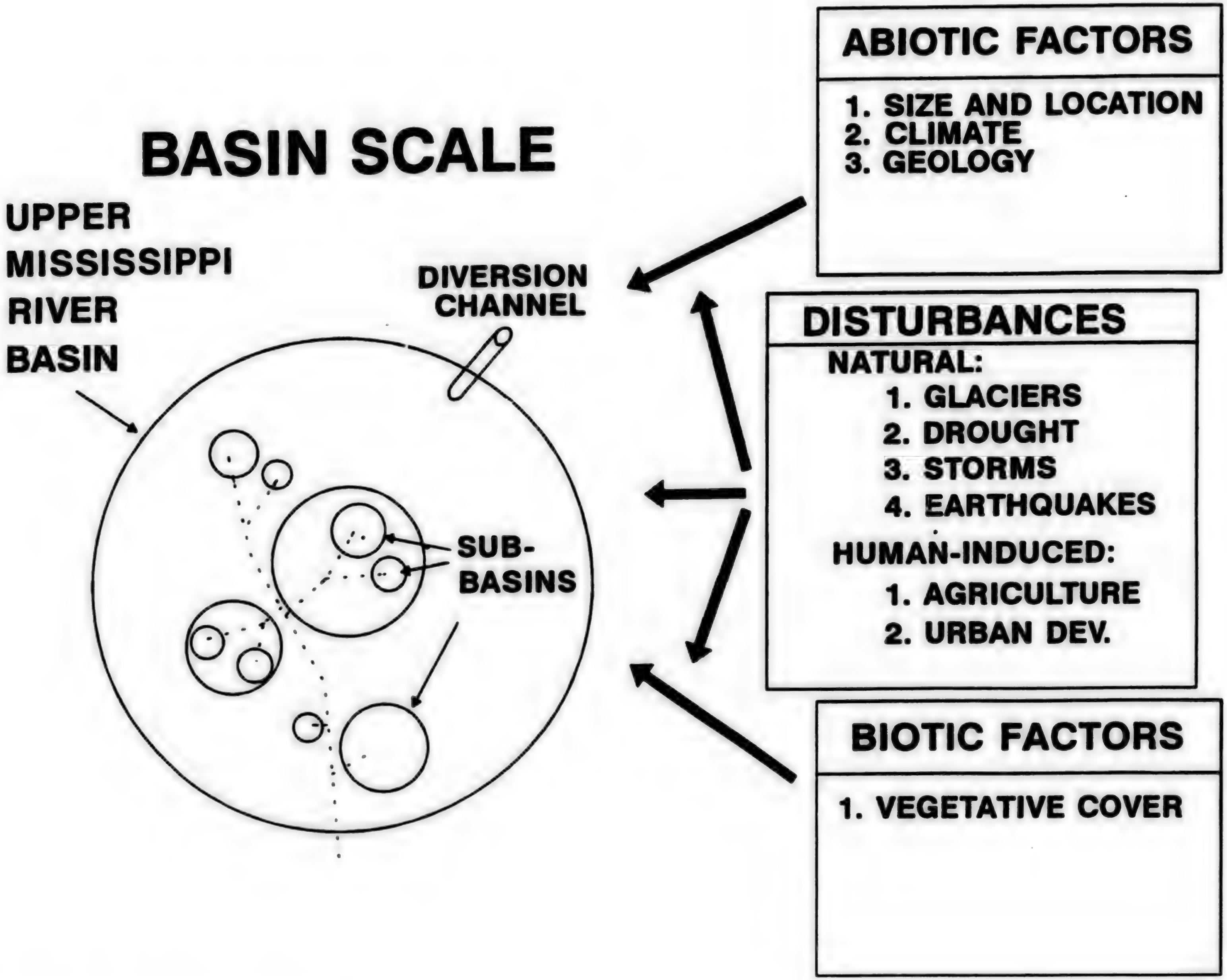


Figure 4. The basin spatial scale

northern edge of the Basin can lag behind (in the spring) or precede (in the fall) those at the southern edge by 2 to 4 weeks. Annual freeze-free periods range from 90 d in the north (excepting the mountainous area of the Missouri Subbasin) to 180 d in the south.

Several associations between global and regional climate patterns and aquatic ecosystem structures are being explored (Blumberg and DiToro 1990; Magnuson et al. 1990; Regier and Meisner 1990). Efforts to explain how river flows are controlled by large-scale climate patterns are increasing (Knox et al. 1975; Molles and Dahm 1990) and will help forecast ecological changes in the UMRS associated with acid rain or global warming.

Storms and droughts act as natural climatic disturbances at the basin scale. The average annual number of thunderstorm days ranges from 30 d in the north to 60 d in the south (U.S. Army Engineer District, St. Louis et al. 1970).

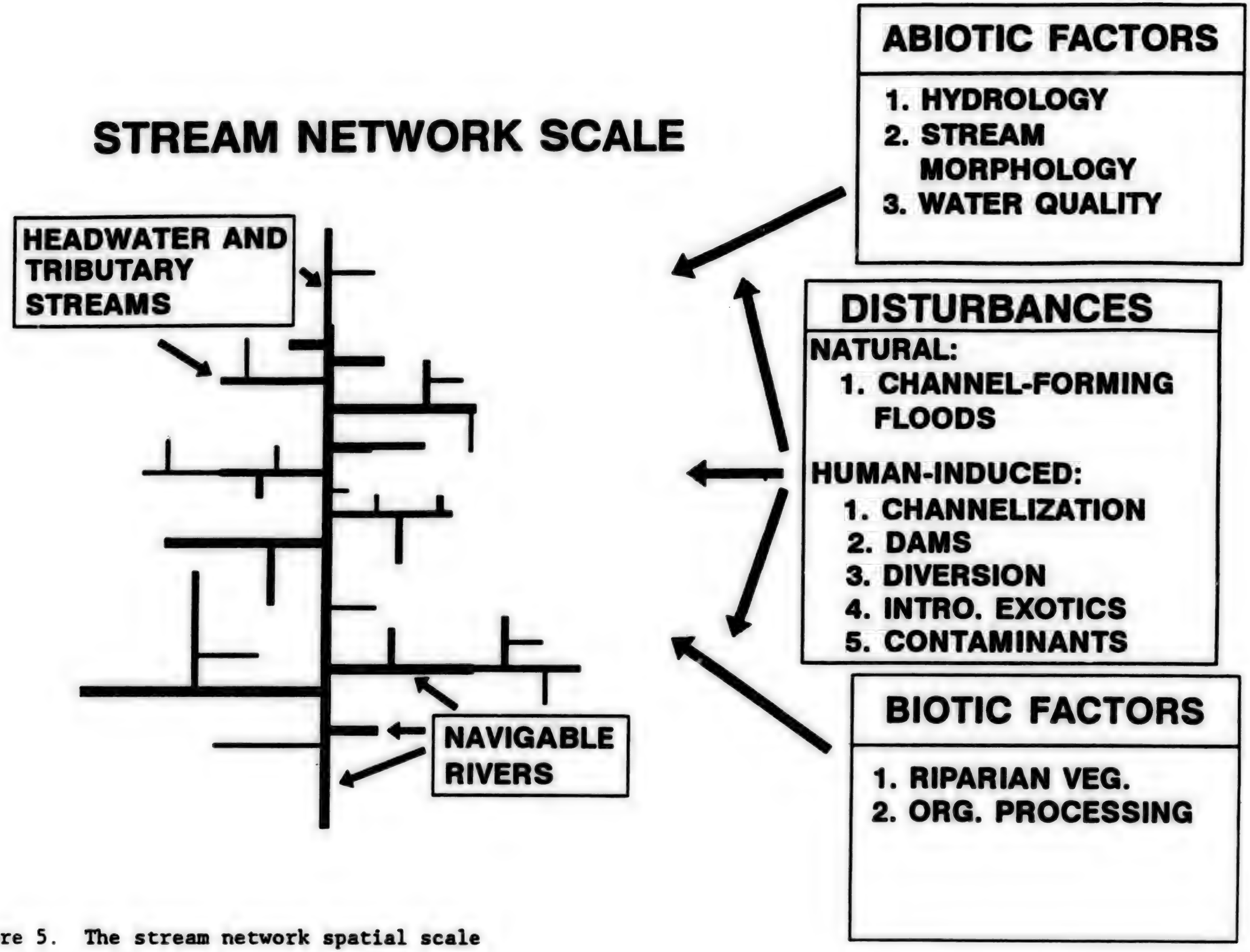
The Basin's vegetative cover, controlled by the climatic and geological factors noted above, plays a major role in controlling ecosystem structure and function. In the absence of human disturbance, the vegetation would be dominated by deciduous forest and prairie (Colman 1953; Coe et al. 1986). The soils within the watershed are among the most fertile in the world, and large-scale conversions of prairies and forests to agricultural and urban land (achieved by plowing, clearing, draining, and tilling) have occurred. In 1970, 61% of the combined Upper Mississippi and Illinois Subbasins was in cropland (USDA 1970). These conversions have had major impacts on water quality and sediment transport at the next spatial scale.

Stream Network Scale

A stream network includes the water-carrying channels that lie above a defined location in a basin. The river reaches of the UMRS are among the largest rivers in the stream network above Cairo, Illinois. These reaches are morphologically and functionally similar to many of their larger tributaries, but are distinguishable because they support commercial navigation (Figs. 1, 5).

At the stream network scale, longitudinal gradients are emphasized (Vannote et al. 1980; Minshall et al. 1985; Ward 1989a). Stream morphology gradually changes downstream in response to a combination of geologic and hydrologic variables (Leopold et al. 1964). Water quality gradients occur as water and materials processed during transport are mixed with flows from tributaries, stream banks, or beds.

Runoff, and, to a lesser extent, groundwater flow, point source discharges, and interbasin diversions of water, links the UMRS stream network to the basin. Major periods of water and material transport to the stream network are associated with snowmelt and spring and fall rains.



STREAM NETWORK SCALE

HEADWATER AND TRIBUTARY STREAMS

NAVIGABLE RIVERS

ABIOTIC FACTORS

1. HYDROLOGY
2. STREAM MORPHOLOGY
3. WATER QUALITY

DISTURBANCES

NATURAL:

1. CHANNEL-FORMING FLOODS

HUMAN-INDUCED:

1. CHANNELIZATION
2. DAMS
3. DIVERSION
4. INTRO. EXOTICS
5. CONTAMINANTS

BIOTIC FACTORS

1. RIPARIAN VEG.
2. ORG. PROCESSING

Figure 5. The stream network spatial scale

The vertical gradients of the major Upper Mississippi and Illinois Rivers' tributaries are greater than those of the main stems (Nielsen et al. 1984; Fig. 6). As a result, UMRS floodplains were aggrading with alluvium even during the presettlement period. However, land use changes, stream channelizations designed to transport water rapidly off the basin, and the construction of dams have greatly accelerated the aggradation rate. The Illinois River has been impacted more by sedimentation than the Mississippi River because of its shallower gradient.

Potential erosion and sediment loadings from tributaries tend to increase downstream on the Upper Mississippi and Illinois Rivers, resulting in increased suspended sediment concentrations. Suspended sediment concentrations in the open Mississippi River (below the mouth of the Missouri River) are relatively high in comparison to upstream reaches. This pattern exists even though the Missouri River, because of the trapping action of upstream reservoirs, presently delivers only one-third of the suspended sediment load it carried around 1700 (Meade, in press).

Floods capable of rerouting channels and reshaping floodplain contours are the most common natural disturbances at the stream network scale. These floods occur on UMRS rivers at frequencies of 100 to 500 yr (U.S. Army Engineer District, St. Paul 1970).

Human-induced disturbances include dams, water diversions, introductions of exotic species, and the release of contaminants. Dams act as human-induced disturbances at this spatial scale by resetting ecological continua backwards (Ward and Stanford 1983), creating tailwaters and increasing velocities immediately downstream, but decreasing velocities and increasing sedimentation rates upstream.

Lake Michigan water is diverted into the UMRS via the Illinois Waterway. The pollutional history of the Illinois River has been well documented (Mills et al. 1966; Starrett 1972). Recent water quality improvements in the Illinois River have been observed, but aquatic macrophytes and benthic invertebrates still have not returned to the middle river reaches since large-scale die-offs occurred in the 1950s. Sediment quality, including composition and toxicity, is a likely limiting factor (Sparks 1984).

Common carp, grass carp, the Asiatic clam, purple loosestrife, and the zebra mussel are among the most well known exotic species that have been introduced into the UMRS. Common carp rapidly became a major component of the fish community and commercial harvest after its introduction in the late 1800s. Asiatic clams were introduced into the UMRS in the 1970s and now are widespread. Purple loosestrife is spreading rapidly throughout the UMRS. The zebra mussel may become a dominant invertebrate in the UMRS in the near future. Differences of opinion exist as to whether these exotics outcompete native species or simply fill available niches in disturbed habitats.

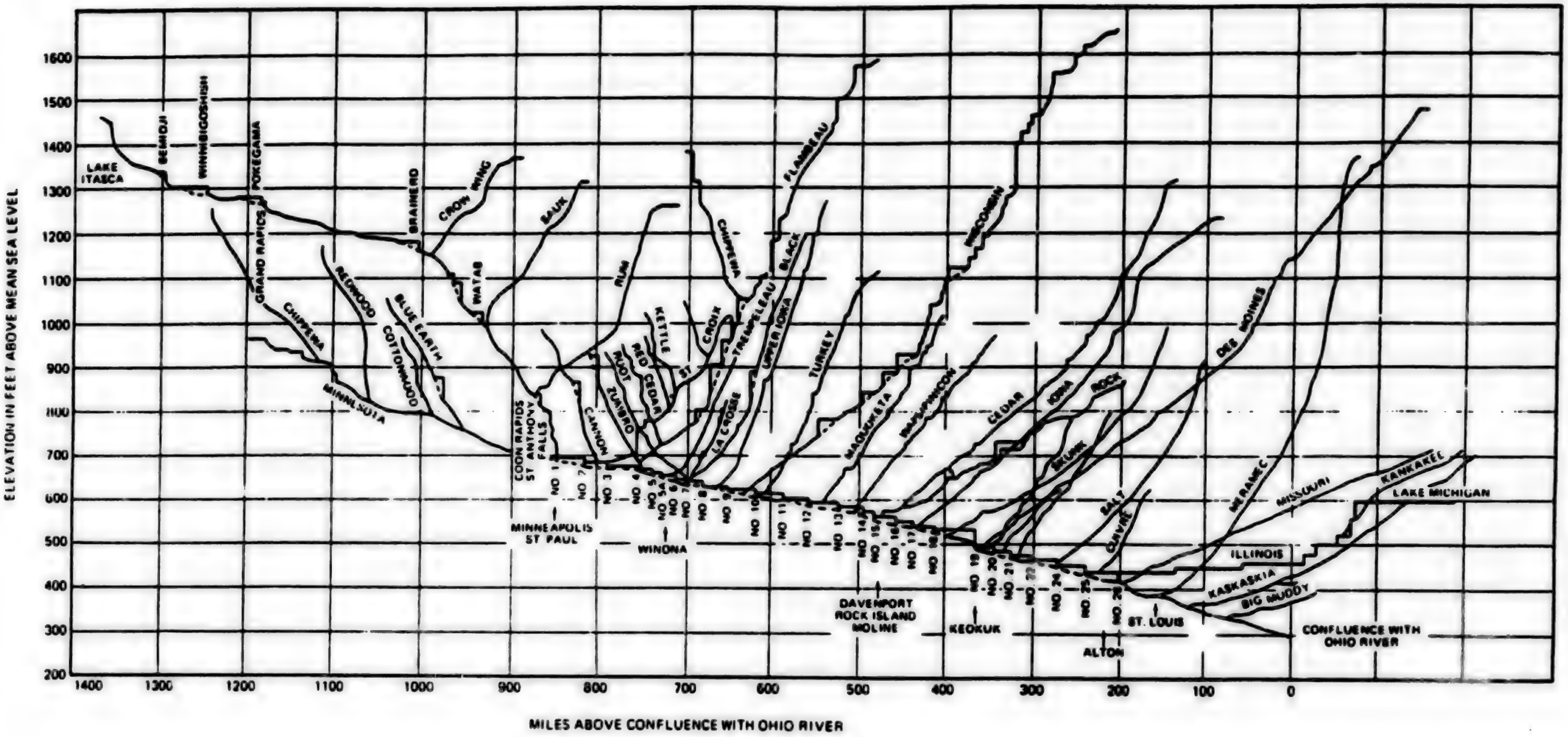


Figure 6. Vertical profiles of major Upper Mississippi River System tributaries (U.S.Army Engineer District, St. Paul, 1970)

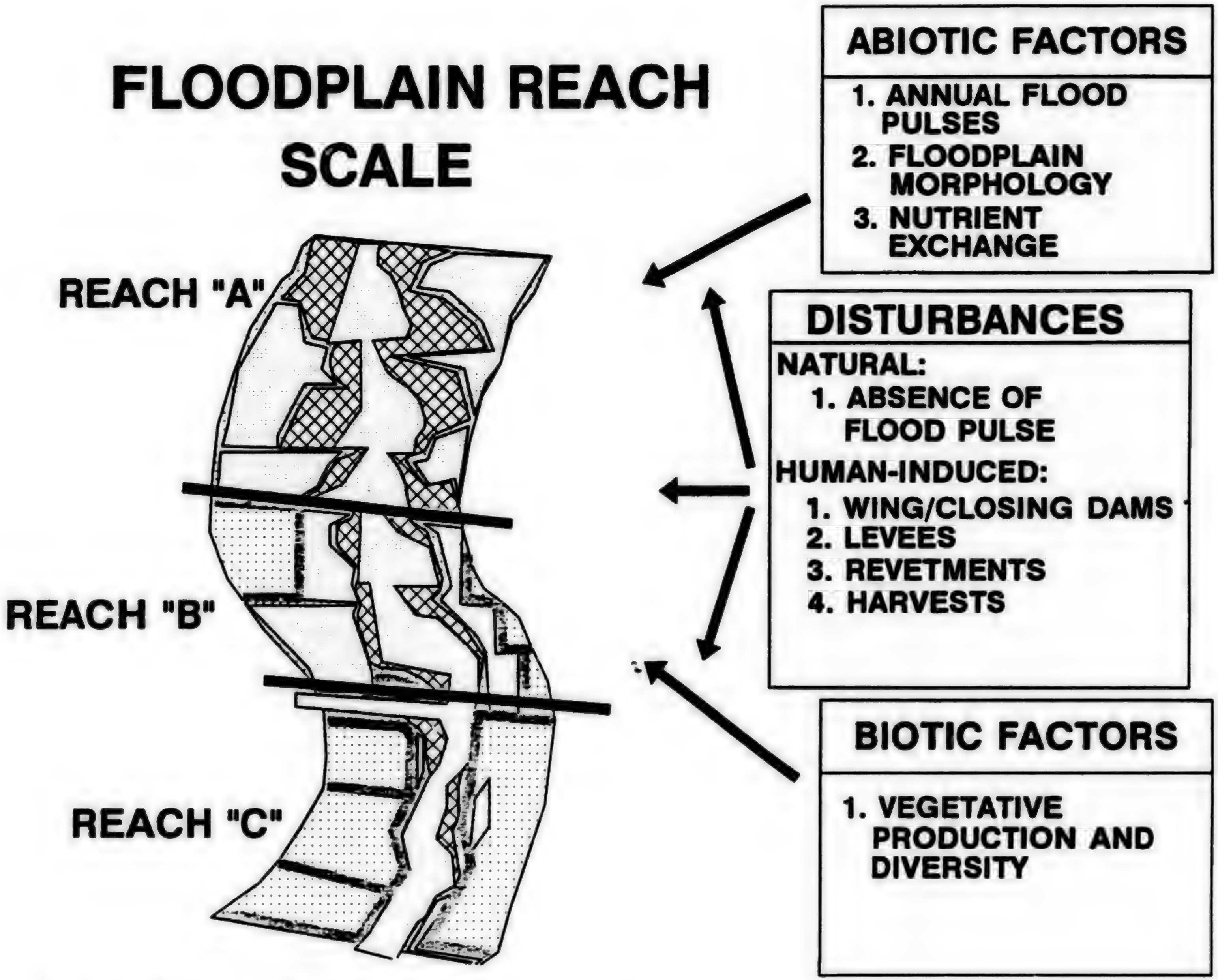
Wiener et al. (1984) provided a recent review of contaminant studies related to the UMRS. Known problem areas include the Illinois River and reaches of the Mississippi River immediately below Minneapolis-St. Paul and St. Louis. Fish consumption advisories for specific river reaches are issued as necessary by each of the five UMRS states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). In the 1970s, advisories based on polychlorinated biphenyl (PCB) concentrations in common carp resulted in sharp declines in the commercial fishery harvest below Minneapolis-St. Paul. One source of PCBs has since been identified and eliminated, and recent data suggest that sediment PCB concentrations in this river reach are now declining. Other contaminants that have been implicated as potential problems in localized UMRS areas are heavy metals, chlordane, and mercury.

Floodplain Reach Scale

The island-braided channels (Shumm 1972; Nielsen et al. 1984) of the UMRS travel through wide alluvial floodplains. The floodplain reach spatial scale recognizes a common theme of large river systems (Sedell et al. 1989), the existence of reaches that are structurally distinguishable and whose ecological characteristics are controlled by the degree of interaction or exchange of materials between the river and its floodplain. Reaches of this type, structured by both natural events and human-induced disturbances, can be identified on the Upper Mississippi and Illinois Rivers.

The Upper Mississippi River includes three floodplain reaches (Fig. 7), based on vegetative cover and the presence of agricultural levees (Gilbertson and Kelly 1981; Peck and Smart 1986). The upper floodplain reach runs from Minneapolis, Minnesota, to Clinton, Iowa, and includes Navigation Pools 1 through 13. This reach contains large areas of off-channel water, large acreages of aquatic vegetation, and few agricultural levees. The middle floodplain reach runs from Clinton, Iowa, to the mouth of the Missouri River, and includes Navigation Pools 14 through 26. The floodplain in this reach contains limited aquatic vegetation, a higher proportion of water in channels, and a moderate amount of land in agricultural levees. The lower floodplain reach runs from the mouth of the Missouri River to Cairo, Illinois. This reach contains almost no aquatic vegetation, a high proportion of water in channels, extensive levees, and no dams. The main navigation channel in this reach has been constricted by numerous wing dams and subsequent sedimentation (Simons et al. 1981).

Two floodplain reaches occur along the Illinois River (Mulvihill and Cornish 1929; Starrett 1972). The upper reach runs between the confluence of the Kankakee and Des Plaines Rivers and Hennepin, Illinois. This reach passes through a young geological valley and has a relatively high gradient and narrow floodplain. Three navigation dams occur along this reach. The lower floodplain reach runs from Hennepin, Illinois, to the Mississippi River. The valley of this reach is geologically older and wider than the upper reach. It was used by the Mississippi River before recent glacial activity redirected the Mississippi channel westward. The lower reach has a very shallow gradient, has been extensively levied, and contains two navigation dams.



FLOODPLAIN REACH SCALE

ABIOTIC FACTORS

1. ANNUAL FLOOD PULSES
2. FLOODPLAIN MORPHOLOGY
3. NUTRIENT EXCHANGE

DISTURBANCES

NATURAL:

1. ABSENCE OF FLOOD PULSE

HUMAN-INDUCED:

1. WING/CLOSING DAMS
2. LEVEES
3. REVETMENTS
4. HARVESTS

BIOTIC FACTORS

1. VEGETATIVE PRODUCTION AND DIVERSITY

Figure 7. The floodplain reach spatial scale

The natural floodplain lakes that occur on the UMRS represent exceptions to the typical channel/floodplain pattern in their respective reaches. Lake Pepin occurs in the upper floodplain reach of the Upper Mississippi River, is 21 mi in length, and was formed by an alluvial delta of the Chippewa River. Peoria Lake, 20 mi in length, occurs in the lower floodplain river reach of the Illinois River. It was formed by alluvial deltas of Tenmile Creek and Farm Creek. The lateral extent of these lakes covers much of the available floodplain.

Major abiotic factors at the floodplain reach spatial scale include the annual flood pulse (Junk et al. 1989) and floodplain morphology. These two factors control the amount of land that is flooded at moderate to high river discharges. The area that is intermittently flooded is called the Aquatic/Terrestrial Transition Zone (Junk et al. 1989).

The annual discharge regime of UMRS rivers is typically bimodal. The regime is characterized by a large spring flood pulse associated with snowmelt (March through April) and spring rains (March through June), and a smaller, less predictable, fall flood pulse associated with fall rains (late August to mid-October). As a result of flow integration as water passes through the stream network, the annual discharge regimes of UMRS rivers tend to be smoother and more predictable than those of progressively smaller tributaries.

The absence of a flood pulse, resulting from a lack of precipitation, is a natural disturbance at the floodplain reach spatial scale (Sparks et al. 1990). In the absence of floods, carbon and nutrient exchange between the UMRS rivers and floodplains is limited, plant life histories are interrupted, and certain fishes cannot use spawning and nursery areas on the floodplain (Ward 1989b).

Human-induced disturbances at the floodplain reach spatial scale include physical modifications to the floodplain and overharvests of floodplain plants and animals. Wing dams, closing dams, and revetments have been constructed on UMRS reaches to aid navigation by confining river flows to narrow channels. These structures can increase sedimentation rates, alter water level regimes, and prevent channel meandering and natural succession. Agricultural levees eliminate interactions between rivers and their floodplains at moderate to high discharges, and increase flood peaks.

Trees, mussels, and fishes in the UMRS have been harvested at levels resulting in species losses or changes in population structure. The lumber industry peaked in the mid- to late 1800s. Mussels were severely impacted by commercial harvests in the early 1900s and are again in jeopardy from exploitation by the cultured pearl industry. Each of the five UMRS states has an active program to detect and reduce overexploitation of UMRS fishery resources.

Navigation Pool Scale

The navigation pool scale is unique among the spatial scales because it is directly associated with a human-induced disturbance. This scale focuses on the ecological changes associated with the operation of the 35 navigation dams on the Upper Mississippi and Illinois Rivers. Major factors at this scale are the same as those at the floodplain reach scale.

A navigation pool, by definition, includes all of the water between one dam and the next dam upstream (Fig. 8). Navigation dams on the UMRS raise upstream surface water elevations to varying degrees, depending on the lift required to create a 9-ft channel, the pool length, and the river gradient.

UMRS navigation dams are designed to pass flood flows without raising flood peaks, the one exception being the Keokuk Dam, which provides hydroelectricity as well as a navigational channel. At moderate to high river discharges, gates in the dams are lifted out of the water or are dropped to the bottom of the river to pass flood flows. Since floods of this magnitude occur almost annually, the navigation pools are considered intermittent, low flow impoundments.

The impacts of navigation dams on longitudinal river gradients (i.e., water quality, velocity, sedimentation rates) are evaluated at the stream network scale. At the navigation pool scale, impacts associated with changes in water levels are emphasized. Because water levels in navigation pools are no longer allowed to drop below certain elevations, some floodplain areas that used to become dry during summers are now permanently wet and will remain so until sedimentation results in the succession of these areas to terrestrial habitats. Organic and nutrient cycling between the soils of these pools and the river has decreased.

The conversion of terrestrial to aquatic habitats that accompanied the construction of the navigation dams has been well documented (Peck and Smart 1986).

At low to moderate discharges, navigation dams are operated to keep water levels at a specific location in the pool as constant as possible. This location is called the hinge point (HP in Fig. 8) of the pool. In pools where the hinge point is at the downstream dam, water levels fluctuate most in the upper reaches of the pool (TW in Fig. 8) and least in the lower reaches of the pool (PL in Fig. 8). However, in some cases the hinge point is in the middle of the pool. Then, during rising discharge periods, the water level in the lower reach of one of these pools can actually fall while the water level in the upper reach is rising. Operating the navigation dams can disrupt the discharge/water level relationship at a site, disturbing near-shore biota.

Because the gates in navigation dams are pulled out of the water during flood periods, the dams do not completely prohibit fish migrations. However, high velocities created below dam gates during low to moderate river discharges do reduce fish movement from one navigation pool to another. Water flows over the gates or through the hydroelectric plant at the Keokuk Dam, the greatest barrier to fish migration on the UMRS.

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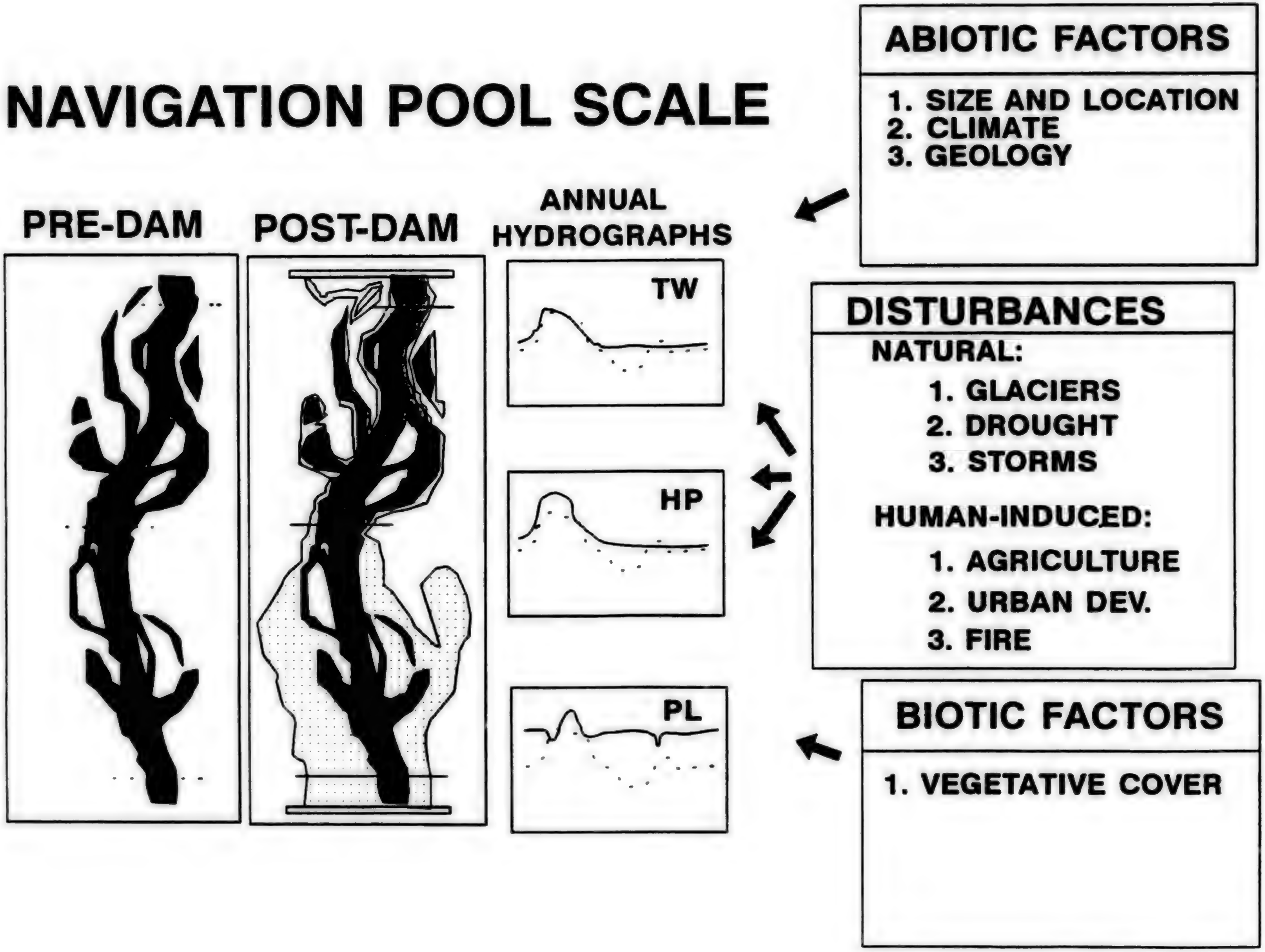


ABIOTIC FACTORS

1. SIZE AND LOCATION
2. CLIMATE
3. GEOLOGY

DISTURBANCES

NATURAL:

1. GLACIERS
2. DROUGHT
3. STORMS

HUMAN-INDUCED:

1. AGRICULTURE
2. URBAN DEV.
3. FIRE

BIOTIC FACTORS

1. VEGETATIVE COVER

Figure 8. The navigation pool scale. The hydrographs represent water level conditions at three locations where daily water levels are typically recorded (TW - tailwater; HP - hinge point; PL - pool).

Habitat Scale

The habitat spatial scale addresses fine structural heterogeneities in UMRS floodplains and aquatic areas. Figure 9 illustrates four aquatic habitat categories.

Habitat categories are defined by a combination of geomorphological and physical variables. Major factors characterizing UMRS aquatic habitats include velocity, substrate type, dissolved oxygen, temperature, turbidity, cover, and depth. In addition to determining the value of habitat categories to aquatic populations, these factors influence the extent to which habitats are impacted by disturbances at this and larger spatial scales.

The importance of the habitat spatial scale is linked to the tendency of many plant and animal species to associate with certain habitat categories. These associations can be viewed as functional attributes of the habitat. The UMRS rivers provide a variety of habitats for resident and migratory animal species.

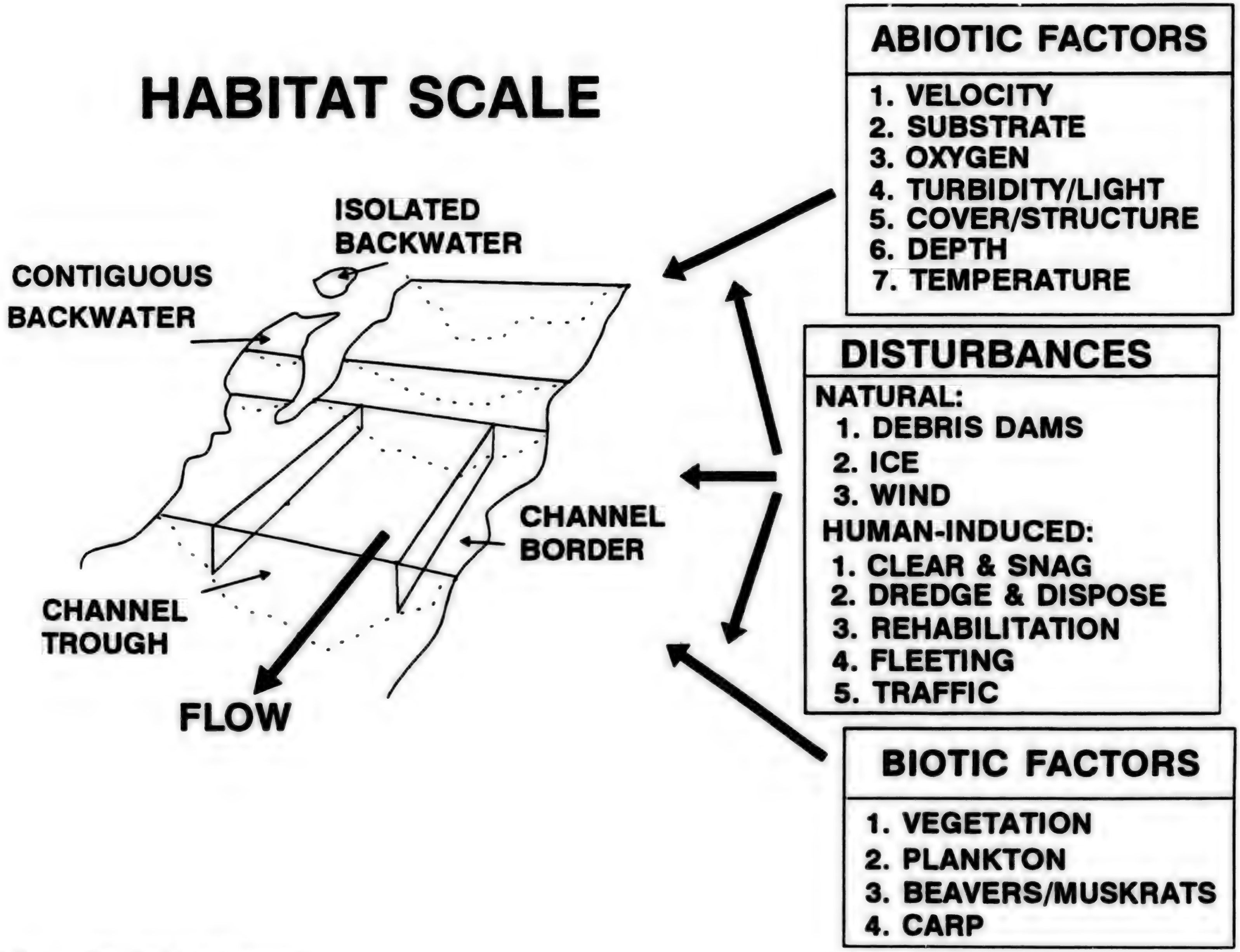
Habitat templates for lotic systems are not easily quantified (Poff and Ward 1990). Several classification systems for UMRS aquatic habitats have been proposed (Rasmussen 1979; Cobb and Clark 1981). However, the variable UMRS water levels and discharges prohibit applying habitat labels to specific locations.

Natural disturbances at the habitat scale are local events resulting in changes in one or more major factors. These disturbances include the formation or dislodging of debris or ice dams and wind. Human-induced disturbances that have the same effects include clearing and snagging operations to promote boat traffic, dredging and the disposal of dredged material, habitat rehabilitation, barge fleeting, and commercial and recreational traffic.

Boat traffic is an example of a disturbance that acts at a small spatial scale but that can have cumulative impacts. For example, bank erosion can result from the cumulative impacts of waves created by repetitive traffic at the same location. In addition, small-scale impacts among sites can accumulate to have a greater impact at a larger spatial scale.

Linking the Conceptual Model to the LTRMP

The LTRMP conceptual model is intended to be dynamic and is subject to elaboration or modification in response to new information. Model revisions may also require changes in LTRMP monitoring and research strategies. The model will be used to support Program decisions in several areas, including (1) identifying and prioritizing resource problems for investigation, (2) selecting resource components for monitoring, (3) developing strategic models and identifying cause-and-effect relationships to be quantified, and



ABIOTIC FACTORS

1. VELOCITY
2. SUBSTRATE
3. OXYGEN
4. TURBIDITY/LIGHT
5. COVER/STRUCTURE
6. DEPTH
7. TEMPERATURE

DISTURBANCES

NATURAL:
1. DEBRIS DAMS
2. ICE
3. WIND

HUMAN-INDUCED:
1. CLEAR & SNAG
2. DREDGE & DISPOSE
3. REHABILITATION
4. FLEETING
5. TRAFFIC

BIOTIC FACTORS

1. VEGETATION
2. PLANKTON
3. BEAVERS/MUSKRATS
4. CARP

Figure 9. The habitat scale

(4) selecting appropriate experimental designs. Although the conceptual model was not fully developed when the Program was initiated, many of the ideas contained in the model were well known and were used during the pre-Program decision-making process in each of these areas.

The LTRMP is problem oriented. Program decisions related to pertinent subject matter favor studies that document cause-and-effect relationships and spatial or temporal patterns, or that evaluate solutions to high priority resource problems. Sedimentation, increased navigation, and water level fluctuations are three high priority resource problems currently under investigation. Regular model revisions will provide a mechanism for redirecting Program priorities, as necessary, toward growing resource problems. Model revisions also will help identify whether the magnitude of a resource problem has changed or will show how the problem and its potential solution vary across different spatial scales within the UMRS. For example, the conceptual model helps to illustrate the point that while the impacts of sedimentation on abiotic and biotic factors (substrate, turbidity, depth, vegetation) occur at the habitat scale, many disturbances that produce increased sedimentation (impoundment, tributary channelization, agricultural development) and therefore its long term solution, need to be addressed at larger spatial scales.

Several criteria have been used to select resource components for long term monitoring. The model focuses on criteria that are based on ecological properties. For instance, water quality and vegetation are major factors in the model because they can control ecosystem structure and function at several scales. If new information reveals that important abiotic or biotic controlling factors are not being monitored, these can be added to the list of resource components.

The conceptual model provides a reference framework for constructing strategic models related to the resource problems under investigation. A strategic model is a box-and-arrow representation of the cause-and-effect relationships affecting a resource component across different spatial scales. Strategic models will be constructed for each resource problem component combination to identify and prioritize relationships that will be quantified through LTRMP experimentation. The conceptual model will be used as a guide to the construction of these strategic models and to ensure that they address cause-and-effect mechanisms that occur across different spatial scales.

Within the LTRMP, experimental design refers to selecting sampling sites and frequencies, either for monitoring resource components or for quantifying cause-and-effect relationships. Field stations monitoring resource components were sited in recognition of the floodplain reach spatial scale described in the conceptual model. The selection of sampling sites for the water quality and fish resource components has been based on hypotheses related to differences at the habitat spatial scale. Sampling frequencies have focused on anticipated changes related to disturbances, and as a result have been based on known or assumed variances over the reference periods described in the model. The model will continue to be used extensively in establishing future experimental designs for the LTRMP.

Summary

The conceptual model describes major ecological factors and disturbances that operate at several spatial scales in the river reaches of the UMRS. The model is intended to provide an ecological basis for setting priorities, selecting resource components to be monitored, establishing strategic models, and guiding experimental designs within the LTRMP. The model will be revised as necessary in response to new information related to ecosystem structure, function, or disturbances.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, D.C. 20503

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
March 1993

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
A Conceptual Model of the Upper Mississippi River System Ecosystem

5. FUNDING NUMBERS

6. AUTHOR(S)
Ken Lubinski

7. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
93-T001

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Monitoring and research strategies of the Long Term Resource Monitoring Program require a current, objective understanding of the factors that control ecological structure and function of floodplain reaches within the Upper Mississippi River System. The conceptual model presented here is designed to fill part of this need by listing major factors (abiotic and biotic) and disturbances (natural and human-induced) that operate at each of five spatial scales. In decreasing order of size, the spatial scales include: basin, stream network, floodplain reach, navigation pool, and habitat. Major factors are defined as those which act to keep ecosystem variables within predictable limits over a reference time period. A disturbance is an event that disrupts structure or function at the ecosystem, community or population level of biological integration. The conceptual model is meant to be dynamic, and will be modified as new information becomes available, so that research and monitoring strategies can be adjusted annually in response to unanticipated resource problems.

14. SUBJECT TERMS
Floodplain river, ecosystem, monitoring, Mississippi River, Illinois River, research strategy, disturbance, model

15. NUMBER OF PAGES
23 pp.

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

24

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information to maintain the Upper Mississippi River System as a viable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

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10/24/95